ENHANCED BIOREMEDIATION SOURCE CONTROL WORK PLAN

prepared for:

SILTRONIC CORPORATION

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Project No. 8128.01.20

prepared by:

860037

MAUL FOSTER ALONGI INC.
ENVIRONMENTAL & ENGINEERING CONSULTANTS
Vancouver, WA | Portland, OR | www.MFAinc.org

May 12, 2008

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Maul Foster & Alongi, Inc.
3121 SW Moody Avenue, Suite 200
Portland, Oregon 97239

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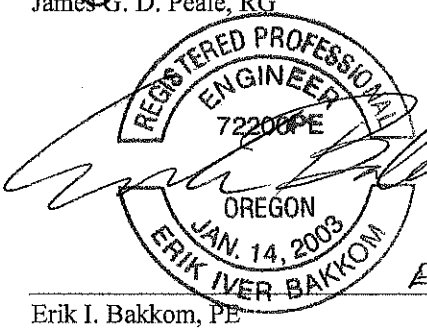
Enhanced Bioremediation Source Control Work Plan
Siltronic Corporation

The material and data in this report were prepared under the supervision and direction of the undersigned.

Maul Foster & Alongi, Inc.

James G. D. Peale, RG



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Erik I. Bakkom, PE

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CVOC	chlorinated volatile organic compound
DCE	dichloroethene
DEQ	Oregon Department of Environmental Quality
DNAPL	dense nonaqueous-phase liquid
EIB	enhanced *in-situ* bioremediation
EPA	U.S. Environmental Protection Agency
FFS	Focused Feasibility Study
JSCS	Joint Source Control Strategy
MRL	method reporting limit
MFA	Maul Foster & Alongi, Inc.
µg/L	micrograms per liter
NWN	NW Natural
OAR	Oregon Administrative Rules
the Order	*Order Requiring Remedial Investigation and Source Control Measures*
PMW	performance monitoring well
PRB	permeable reactive barrier
RAO	Remedial Action Objective
RI	remedial investigation
SCM	source control measure
Siltronic	Siltronic Corporation
SLV	screening level value
TCE	Trichloroethene
UIC	underground injection control
UST	underground storage tank
Work Plan	Source Control Work Plan

1 INTRODUCTION

Maul Foster & Alongi, Inc. (MFA) has prepared this Source Control Work Plan (the Work Plan) for enhanced *in-situ* bioremediation (EIB) of trichloroethene (TCE) and its degradation products (specifically, cis-1,2-dichloroethene [DCE], trans-1,2-DCE, and vinyl chloride) at the Siltronic Corporation (Siltronic) facility located at 7200 NW Front Avenue, Portland, Oregon (see Figure 1-1).

As applied at Siltronic, EIB will be accomplished by subsurface injection of a combination of a naturally occurring microbial inoculum (KB-1™ by SiREM Laboratory[1]) and a slow release carbon source with zero-valent iron (EHC® by Adventus Americas, Inc.[2]). The EIB approach provides multiple and redundant pathways for rapidly transforming TCE and its degradation products into fully dechlorinated aliphatics (e.g., ethene and ethane) and non-toxic products.

The Work Plan includes the following sections:

Section 1 provides a summary of the work completed to date, and includes an update to the Pilot Study data from the source area.

Section 2 restates the Remedial Action Objective (RAO) for the source area from the Focused Feasibility Study (FFS), and addresses regulatory comments related to meeting the RAO.

Section 3 identifies the implementation approach, including determination of the injection area; description of the injection methods, materials and equipment; and monitoring and reporting requirements.

Section 4 describes the criteria for evaluating the success of the source control work, and identifies criteria for evaluating the need for supplemental work or expansion of the implementation approach.

Section 5 provides an estimated project schedule for 2008.

[1] KB-1™ is a registered trademark of SiREM Laboratory.
[2] EHC™ is a registered trademark of Adventus Intellectual Property Inc.

1.1 Work Completed

Siltronic has completed a remedial investigation (RI) and submitted an RI Report to the Oregon Department of Environmental Quality (DEQ) and the U.S. Environmental Protection Agency (EPA) in April, 2007 (MFA, 2007a).[3] This work was performed in compliance with the *Order Requiring Remedial Investigation and Source Control Measures* (the Order), DEQ No. VC-NWR-03-16, issued to Siltronic on February 9, 2004.

Section 5.B of the Order states that Siltronic shall identify and evaluate source control measures (SCM), and that the DEQ will review and approve these measures pursuant to Oregon Administrative Rules (OAR) 340-122-0070 and through consultation with the EPA. In response to the requirements of Section 5.B, Siltronic completed the following:

- A technology screening evaluation (MFA, 2005);
- Bench test of three *in-situ* bioremediation alternatives (MFA, 2006);
- Field pilot study of EIB consistent with OAR 340-122-0070 and related regulations OAR 340-122-0040(1), (5), and (6) (MFA, 2007b); and
- FFS consistent with EPA and DEQ guidance and regulations (MFA, 2007c).[4]

The Siltronic FFS recommended application of EIB in the source area and at the riverbank (Figure 1-2), consistent with the goals and objectives of the Portland Harbor Joint Source Control Strategy (JSCS) (EPA and DEQ, 2005). DEQ agreed with Siltronic's recommendation for the source area, but did not approve of EIB at the riverbank (DEQ, 2008). Instead, DEQ directed Siltronic to cooperate with riverbank SCM as proposed by NW Natural (NWN).

To date, EPA has not provided written concurrence or disapproval of the FFS, but has indicated that Siltronic's approach for the riverbank should be considered as a component of a comprehensive remedy for upland and in-river impacts.[5] EPA and DEQ are not expected to resolve this apparent difference of opinions until after submittal of this

[3] To date, neither agency has provided comments regarding the RI Report.

[4] Specifically, consistent with guidance from the EPA (EPA, 1988, 1993a) and therefore consistent with the National Contingency Plan, as required for Comprehensive Environmental Response, Compensation, and Liability Act actions; and consistent with the removal requirement of OAR 340-122-0070 and satisfying OAR 340-122-0040(1), (5), and (6); and OAR 340-122-0085 and 340-122-0090.

[5] As discussed in meetings between Siltronic, EPA and NWN on March 21, 2008 and April 18, 2008.

document. Accordingly, this Work Plan is limited to SCM for the source area.[6] In the event that EIB at the riverbank is approved by the agencies, this document will be amended to include implementation of an EIB permeable reactive barrier (PRB) at the riverbank.

In the event that EPA and DEQ concur that EIB is not to be implemented at the riverbank, Siltronic will limit its riverbank efforts to cooperative implementation of NWN's proposed SCM. This outcome will be consistent with Alternative 2B of the Siltronic FFS, and will likely require a monitored natural attenuation remedy for Area 1. Siltronic's cooperation with NWN, along with implementation of EIB in the source area, will therefore fulfill Siltronic's obligations under the Order.

1.2 Site Conditions

The FFS recommended application of EIB in the source area based upon the success of the Pilot Study work, which was completed and documented in the EIB Pilot Study Report.[7] The pilot study wells (within and downgradient of the EIB-PRB) were incorporated into the quarterly monitoring program for the facility, and additional data (through February 2008, which are included as Appendix A) have confirmed the success of the approach, as discussed below.

1.2.1 EIB-PRB Wells—WS-19-71/101

Figure 1-3 summarizes the results for TCE and its degradation products from the wells located within the pilot study EIB-PRB—WS-19-71 and WS-19-101. These wells are screened from 60-70 and 90-100 feet, respectively. The data confirm the EIB has successfully met the RAO as stated in the FFS—TCE has been treated such that concentrations do not indicate the presence of dense nonaqueous phase liquid (DNAPL). In fact, TCE was not present above the method reporting limit (MRL) in the shallow well, and was only 0.37 micrograms per liter (µg/L) (i.e., 0.07 µg/L above the MRL) in the deep well during the most recent sampling event.

During the pilot study monitoring period, concentrations of cis-1,2-DCE declined in the shallow well, but remained unchanged in the deep well. Subsequently, concentrations in both wells declined significantly—by approximately three orders of magnitude relative to the starting data—such that recent concentrations are less than 100 µg/L. This decrease

[6] Siltronic is also evaluating the stormwater pathway consistent with JSCS guidance; however, the stormwater system is not a pathway for TCE or its degradation products and is not addressed by the Order.

[7] Submitted to DEQ on August 9, 2007.

reflects the removal of TCE (i.e., the source of the cis-1,2-DCE), and is characteristic of sequential dechlorination.

At the start of the pilot study, the vinyl chloride concentrations were much lower than the parent products (generally less than 100 µg/L) suggesting only partial dechlorination. Immediately after injection, concentrations of vinyl chloride and ethene increased, confirming that EIB was completing the dechlorination. The rate of the vinyl chloride increase was approximately the same as the rate of the TCE decrease, confirming that no net accumulation of cis-1,2-DCE was occurring. This pattern would suggest that a decrease in cis-1,2-DCE would be followed by a similar decrease in vinyl chloride. In fact, Figure 1-4 (which includes the ethene concentrations) confirms these mechanisms—concentrations of vinyl chloride decreased significantly (by between one to two orders of magnitude) once the cis-1,2-DCE concentrations began to trend downward. Recent concentrations of vinyl chloride ranged from 156 µg/L (in the deep well) to 10,500 µg/L (in the shallow well).

1.2.2 Downgradient Wells—WS-18-71/101

Figure 1-4 summarizes the data for these wells, which are screened at the same elevations as the EIB-PRB wells, and are located approximately 10-12 feet downgradient of the EIB-PRB wells. The trends evident in Figures 1-3 and 1-4 are evident in Figures 1-5 and 1-6 (albeit with some delay relative to the PRB wells), confirming that the mechanisms operating within the PRB are also operating downgradient of the PRB.

2 REMEDIAL ACTION OBJECTIVE

As stated in the FFS, the RAO for the source area is to reduce concentrations of TCE in groundwater such that they are not representative of TCE DNAPL. In their comments on the FFS, DEQ required the following conditions for implementing EIB in the source area:

1. Revise the RAO to include meeting JSCS screening level values (SLVs) at the riverbank, and preventing downgradient expansion of the chlorinated volatile organic compound (CVOC) plume, in the context of hydraulic gradients created by the NWN SCM.

2. Further delineation of the lateral and vertical extent of CVOCs is required, and should identify the lateral and vertical extent of TCE exceeding 11,000 µg/L (approximately 1 percent of the aqueous solubility of TCE).

3. Implementation should occur prior to implementation of NWN's SCM at the riverbank.

4. Additional groundwater monitoring points should be placed between the EIB injection zone and the riverbank.

In general, the revised RAO can be met using the approach recommended in the FFS (i.e., injection of EHC and KB-1) with groundwater monitoring to document effectiveness and determine the need for potential re-injections. The following sections address DEQ's required conditions.

2.1 Condition 1—Revised RAO

The data (discussed in Section 1) demonstrate the success of the EIB PRB for not only meeting the source area RAO as stated in the FFS, but also the revised RAO as suggested by DEQ. Based on the pilot study data, the EIB PRB will reduce concentrations of TCE and its degradation products to below JSCS SLVs. The absence of a net accumulation of cis-1,2-DCE confirms that an expanded plume of this daughter product is not a likely outcome. The vinyl chloride data suggest that elevated levels of this daughter product are temporary.

As discussed in Section 3, monitoring wells located downgradient of Fab 1 will provide data to document performance of EIB in the context of this condition. Additional characterization data will be incorporated into the monitoring program in order to estimate the extent to which the temporary elevated concentrations of vinyl chloride may persist.

To date, a detailed groundwater model that identifies the "hydraulic gradients imposed by a series of extraction wells at the river bank" has not been completed. However, it is unlikely that implementation of EIB in the source area, followed by groundwater extraction at the riverbank, will result in a net expansion of the CVOC plume. Increased groundwater extraction will likely reduce the lateral extent of the CVOC plume in the upland. The extent to which groundwater extraction will reduce the portion of the CVOC plume downgradient of the extraction wells has not been predicted by the NWN model. The analysis in the Siltronic FFS demonstrated that DEQ's recommended approach will leave over half the CVOC plume untreated, in and below the river.

2.2 Condition 2—Further Delineation

Further delineation of the source area is anticipated consistent with the Pre-Injection Scope of Work described in MFA's April 19, 2008 letter to DEQ, which is attached as Appendix B. In short, reconnaissance groundwater samples, pneumatic slug tests, and soil samples (for physical parameters) will be collected from multiple borings in the source area. The results of the sampling will be used to identify the EIB injection zone, which is anticipated to include the lateral and vertical extent of groundwater with concentrations of TCE exceeding 11,000 µg/L.

In their comment regarding the Siltronic FFS, DEQ required soil sampling, in addition to groundwater sampling. Additional soil sampling for CVOCs is not recommended for the following reasons:

- Consistent with the delineation work for the Pilot Study, soil screening for TCE DNAPL is unlikely to provide accurate data due to the high probability for false negatives (Pankow and Cherry, 1996).

- As demonstrated in the RI Report, TCE does not appreciably sorb to soil. The bulk of the TCE (and its degradation products) at the site are dissolved in groundwater. Soil data will therefore not be representative of subsurface impacts requiring source control.

- Consistent with EPA guidance, it is the presence of TCE in *groundwater* at concentrations greater than the 1 percent solubility threshold that suggests the

presence of TCE DNAPL. Soil analytical data will not inform decisions regarding the presence or absence of potential TCE DNAPL and its remediation.

- Soil below the bottom of the former TCE underground storage tank (UST) pit (and below the water table) was overexcavated during tank removal in 1985. Soil impacts that might be characteristic of the release are unlikely to still be present.

The results of the delineation work will be provided as an addendum to this Work Plan when they become available.

2.3 Condition 3—Sequencing

The current schedule for implementation of the NWN SCM at the riverbank is unknown. Based on the schedule identified in the NWN FFS, and the current status of the project, implementation of EIB in the source area is appropriate, and will occur well before implementation of NWN's SCM at the riverbank.

2.4 Condition 4—Additional Monitoring Points

In their comments, DEQ required performance monitoring wells (PMWs) located between the former UST system and the riverbank. After clarification during a scoping meeting, DEQ indicated that PMWs located downgradient of the Fab 1 building would be required. These monitoring points would be in addition to the monitoring points proposed for the source area. The objective of the additional points is to document that JSCS SLVs have been met at the riverbank.[8] The monitoring well locations and the monitoring schedule are described in Section 3.

The revised RAO thus includes reducing TCE concentrations to below 11,000 µg/L in the source area and reducing concentrations of TCE, cis-1,2-DCE, and vinyl chloride to below relevant JSCS SLVs (30, 61 and 2.4 µg/L, respectively) at the riverbank.

[8] In the event that EPA recommends implementation of EIB at the riverbank, these wells will also provide influent concentration data for performance monitoring.

3 IMPLEMENTATION APPROACH

This section identifies the design and approach for EIB installation, performance monitoring, and reporting. The design will be consistent with the pilot study design, in order to achieve similar success. The methods and equipment used for EIB and well installation will be consistent with those presented in previous work plans approved by DEQ, and based on experience developed during the pilot study. Performance monitoring will consist of groundwater sampling for target compounds on a monthly schedule until clear trends have developed, after which sampling frequency will be reduced. The following sections provide additional detail regarding the implementation components.

3.1 Supplemental Delineation

Additional lateral and vertical delineation of groundwater below the source area is required in order to optimize the EIB design. The primary objective of the delineation is to identify the injection volume; additional data will be helpful for predicting remediation timeframes.

Delineation will consist of direct-push sampling of groundwater, pneumatic slug testing, and soil profiling. Reconnaissance groundwater samples will be collected to delineate the lateral and vertical extent of TCE above the 1 percent threshold. Pneumatic slug tests will be collected from depths corresponding to the reconnaissance groundwater samples to evaluate hydraulic conductivity. Ten borings are proposed for delineation, with the understanding that additional borings may be required.

As discussed in the RI Report, groundwater impacted by TCE and its degradation products is limited to between approximately 25 and 100 feet below ground surface (bgs). The highest concentrations have been detected in groundwater ranging from approximately 50 to 100 feet bgs, in silt-sand mixtures, with sand content increasing with depth. A relatively low-permeability silt layer is present from approximately 100 feet bgs to 150 feet bgs. At DEQ's request, three borings will be profiled for soil stratigraphy, with samples of the underlying silt layer collected for permeability testing.

The scope and details of the delineation, including DEQ's comments and approval, are included as Appendix B.

3.2 Injection Zone Design

In general, the approach consists of injecting EHC and KB-1 in a grid within the injection volume—i.e., the volume of groundwater impacted by TCE greater than 11,000 µg/L (the injection threshold). Once the injection volume has been determined, the design variables are limited to amendment mass and injection grid spacing. In order to replicate the success of the pilot study, no significant changes to the amendment mass requirements are proposed.

3.2.1 Mass Requirements

Both EHC and KB-1 quantities will be based on the volume of soil within the injection footprint. Based on the pilot study, the EHC mass will be calculated as 1.5 percent of the mass of soil in the injection volume, or 150 pounds per injection interval. The KB-1 volume will be 500 milliliters per injection interval, as applied in the pilot study.

The FFS included an estimate of the injection volume for the purposes of providing relative cost data. This volume is expected to change based on the delineation results, but is revised and included in Table 3-1 for the purposes of illustrating the methods for determining the mass requirements once the delineation is complete.

3.2.2 Grid Spacing

EHC can be applied either in a PRB orientation or in a saturation grid. The latter approach is likely to be more appropriate for the source area. Based on the EHC manufacturer recommendations, the pilot study required lateral spacing between injection borings of five feet. The EIB design will remain consistent with this spacing within the injection volume to the extent that access is available. Based on the FFS estimate and incorporating additional information regarding access limitations, as many as 150 injection points could be required.

3.3 EIB Installation Approach

The EIB amendments will be installed using the methods and equipment applied during the pilot study. Injections will be made at four-foot (vertical) intervals, with two-foot offsets by row to ensure complete coverage. EHC slurry will be injected using a bottom-up approach with a pressure-activated tip attached to the direct-push drill rods. Based on the pilot study, injection pressures are expected to range from approximately 200-600 pounds per square inch.

KB-1 will be injected using a bottom-up approach through a standard direct-push groundwater sampling screen. A peristaltic pump will deliver the KB-1 solution to the screen interval. KB-1 injections will follow the EHC injections by at least two weeks, which the estimated time required to establish reducing conditions that will promote growth of the KB-1 bacteria. Reducing conditions (i.e., below -75 millivolts) will be verified prior to injection.

Once the location of the injection grid has been finalized, MFA will coordinate with DEQ regarding permitting of the injection grid consistent with Underground Injection Control (UIC) rules. MFA understands that the injection grid as a whole can be permitted as one UIC system.

3.3.1 Angled Injection Approach

In their comments during the scoping meeting, DEQ directed MFA to evaluate the potential for injecting materials below the Fab 1 building. Based on discussions with subcontractors, direct-push equipment is likely limited to injecting no more than 15 degrees from vertical. At the maximum depth (i.e., approximately 100 ft bgs), this angle could increase the distribution of injected materials by approximately 25 feet beyond vertical borings. However, the risks for lost tools and downhole equipment increases significantly for angled borings, due to the increased potential for deviation and increased non-vertical stress on the direct-push rods. The increased deviation also reduces the certainty of the distribution of injected materials within the target zone.

MFA will further evaluate the limitations of direct-push technology for angled injection, in the event that the delineation data indicate that groundwater concentrations under the building significantly exceed the injection threshold. A pilot angled injection program would likely be appropriate to evaluate feasibility and determine if the added benefit outweighs the potential risk for lost equipment.

3.4 Performance Monitoring Well Installation

PMWs will be installed to document the performance of the EIB grid. PMWs in or adjacent to the injection zone will be installed prior to injection to allow for baseline data collection. The data collected from the PMWs (i.e., concentrations of TCE and its degradation products) will be used to document the performance of the EIB grid and estimate remediation timeframes.

3.4.1 Installation Methods

PMW installation will be completed using the methods and equipment for well installation previously approved by DEQ for the RI and pilot study work. The wells will be installed using a limited-access resonant sonic drilling rig. The wells will be constructed using PVC casing and stainless steel screens, with a one-foot tailpipe installed below the screen to facilitate DNAPL monitoring. De-oxygenated water may be required for downhole drilling fluid in the source area in order to maintain favorable conditions for the anaerobic KB-1 consortium.[9]

As discussed in Section 2.4, DEQ has indicated that additional PMWs located downgradient of Fab 1 will be required. DEQ also directed MFA to evaluate the potential for angled monitoring wells downgradient and below Fab 1, as angled PMWs could provide data ahead of the vertical PMWs. At this time, the potential for installation of PMWs between the injection zone and the upgradient side of Fab 1 still exists, and these wells would likely provide data to satisfy DEQ's concerns regarding downgradient distribution of cis-1,2-DCE and vinyl chloride without the need for angled PMWs. Furthermore, it is not clear that access for angled PMWs is available, since a truck-mounted sonic rig would be required, which would block the access road. Similar to the potential for angled injections, a pilot drilling program may be appropriate.

3.4.2 PMW Locations and Depths

The pilot study relied on performance monitoring data from PMWs installed approximately 10-15 feet downgradient of the EIB PRB. The ability to locate additional PMWs downgradient of the injection zone is contingent upon the results of the delineation work. If adequate space is available, installation of PMWs between the injection zone and the upgradient side of Fab 1 may be appropriate.

In the source area, two additional PMW pairs are proposed: one within the injection grid, and one located between the injection grid and Fab 1 (or at the downgradient extent of the injection grid). Screen elevations will be based upon the concentrations of TCE and its degradation products, such that zones of maximum concentration will be monitored (subject to the extent that stratigraphy allows).[10]

Four additional PMWs will be located downgradient of Fab 1, as close to the building as practicable. Figure 3-1 shows the proposed locations for these riverbank PMWs. The

[9] This water will be made up on site using potable water and sodium sulfite, sodium lactate, or similar reducing agent.

[10] I.e., not within thick silt zones.

proposed screen elevations are based upon the elevation of the maximum detections in the riverbank supplemental delineation borings (completed in 2007).

3.5 Performance Monitoring

As described in the FFS, the monitoring schedule anticipates one year of monthly groundwater sampling from the PMWs, followed by quarterly monitoring. Groundwater samples will be analyzed for the target constituents (TCE and its degradation products) to demonstrate the effectiveness of the EIB grid. Groundwater samples will be collected using dedicated bladder pumps installed in the PMWs.

The existing monitoring wells in the source area will be incorporated into the performance monitoring program. Existing monitoring wells at the riverbank are redundant, but will be incorporated into the performance monitoring until such time as they are rendered ineffective for that purpose by the anticipated groundwater extraction system proposed by NWN.

3.6 Reporting

Based upon the pilot study results, TCE should be reduced to below the injection threshold within six months following injection, which is anticipated to begin in July 2008. The first performance monitoring report will be based upon the baseline and monthly results through the initial six-month period, and could be submitted in early 2009. If early results are not consistent with the pilot study performance data, interim analysis and reports may be appropriate.

4 COMPLETION OF SOURCE CONTROL

The EIB approach will provide contaminant treatment (as opposed to containment) such that meeting the revised RAO (which include quantifiable concentrations) can be conclusively verified. Source control shall be deemed complete when the RAO has been met. This section identifies where the RAO will be met, estimates timeframes for meeting the RAO, and provides criteria for evaluating the need for re-injection.

4.1 Demonstration Points

The primary RAO for the source area is to reduce concentrations of TCE in groundwater to below the injection threshold, or 11,000 µg/L. The existing and proposed PMWs in the source area will be used to document that the RAO has been met.

As discussed in section 2.4, the revised RAO includes meeting JSCS screening levels for TCE and its degradation products at the riverbank. The proposed additional PMWs will be used to document that this revised RAO has been met. The existing monitoring wells along the riverbank (WS-11, WS-12, and WS-14 well pairs, and pilot study wells WS-22-112 and WS-20-112) may provide additional data, but are anticipated to be compromised (with respect to providing representative data) following implementation of NWN's proposed groundwater extraction system. Existing pilot study well WS-21-112 will be incorporated into the PMW system.

In their comments, DEQ expected Siltronic to meet the revised RAO in the context of hydraulic gradients created by NWN's extraction system. At this time, the hydraulic gradients to be created are unknown, and cannot be estimated using the model information provided by Anchor. It is anticipated that a significant body of groundwater elevation measurements will be collected prior to installation of the NWN SCM.

4.2 Conceptual Timeframes for Meeting RAOs

Based upon the pilot study performance, the EIB injection grid is anticipated to reduce TCE concentrations to below the injection threshold in less than approximately three months following injection, and below the JSCS SLV (30 µg/L) in approximately ten months following injection.

The JSCS SLVs for DCE (61 µg/L) and vinyl chloride (2.4 µg/L) have not been achieved in the source area injection zone to date. However, projections based on recent data suggest that these targets could be met by as soon as July 2008—i.e., approximately two years following injection. Figure 4-1 shows the projections for cis-1,2-DCE and vinyl chloride from WS-19-101, based on the recent sampling data.

The conceptual timeframes for meeting the JSCS SLVs in the riverbank PMWs are contingent upon the results of the pneumatic slug testing data, and the anticipated increase in groundwater flow velocity due to the NWN SCM. Absent these data, timeframes for meeting this portion of the RAO cannot be estimated.

Monitoring data from WS-21-112 (upgradient of the riverbank pilot study area), along with pre-pilot study data from WS-11-125, indicate that natural attenuation alone has reduced concentrations of TCE and cis-1,2-DCE to below the JSCS SLVs. If these trends are occurring elsewhere along the riverbank, the revised RAO could be met before implementation of the NWN SCM.

4.3 Re-injection Criteria

The FFS included re-injection of the EIB materials as a contingency, should monitoring data suggest significant differences in performance from the pilot study. Based on the pilot study, the following milestones could be appropriate times for evaluating data from the source area PMWs and making decisions regarding re-injection:

- Injection plus three months. At this time, concentrations of TCE should be below the injection threshold, meeting the TCE-DNAPL portion of the RAO.

- Injection plus ten months. At this time, concentrations of TCE should be below the JSCS SLV.

- Injection plus one year. At this time, groundwater concentrations should reflect the absence of TCE, with cis-1,2-DCE expected to be declining, and vinyl chloride concentrations showing a flat trend.

- Injection plus two years. At this time, concentrations of cis-1,2-DCE and vinyl chloride should be significantly reduced and approaching the JSCS SLVs.

If performance deviates significantly from these trends, additional sampling of performance indicators will be considered. These indicators include concentrations of iron, bacterial cell counts, sulfate or other oxygenated species, and fixed gases. These data will inform decisions regarding which if any amendments are needed.

5 SCHEDULE—2008

The projected schedule (Figure 5-1) reflects unknowns about the scope of the delineation work and the size of the injection grid, and is subject to DEQ's review and comments. At this time, the following milestones are projected:

- Completion of delineation work, including data review and finalization of the injection grid by early June.
- Installation of source area PMWs and baseline sampling completed by mid-June.
- Installation of downgradient PMWs and baseline sampling completed by the end of June.
- Clearing injection grid points for utilities (using air knife) completed by end of June.
- Completion of EHC injection in late August.
- Completion of KB-1 injection by early October.
- Monthly performance monitoring commences in July.

An update to the schedule will be included in the addendum specifying the finalized injection grid.

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TABLES

Table 3-1
Source Zone Injection Specifications
Siltronic Corporation
Portland, Oregon

Description	SZPSA		Unit
	Pilot Study	Proposed Full Scale	
Injection Zone Surface Area	300	3,796	Square Feet
Injection Zone Thickness (Vertical)	56	80	Feet
Top of Injection Zone	50	26	Feet bgs
Bottom of Injection Zone	106	106	Feet bgs
Injection Points	12	158	Each
Vertical Interval	4	4	Feet
Injection Spacing	5	5	Feet
EHC			
Slurry Solids Content	20	20	Percent
Percent EHC by Soil Mass	1.5	1.5	Percent
Amount per Interval	~154	150	Pounds
Mass per Injection Point (Average)	2,271	3,078	Pounds
Total EHC	27,250	486,300	Pounds
KB-1			
Amount per Interval	500	500	milliliters
Amount per Injection Point (Average)	7.3	10.4	Liters
Total KB-1	88.0	1,621	Liters

NOTE:
bgs = below ground surface.

FIGURES

Legend

- Navigation Line
- Siltronic Property Boundary
- Area 1
- Area 2
- Locality of Facility (Based on estimated maximum lateral extent of TCE related groundwater impacts)

Source: Aerial Photograph (2006) obtained from Metro Regional Land Information System (RLIS)

N

0 300 600

Feet

Figure 1-1
Site Location

Siltronic Corporation
Portland, Oregon

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File: X:\8128.01 Siltronic Corp\12\Fig1-1_Site Location.mxd

Project: 8128.01.12 Produced By: T. Vick Approved By: E. Bakkom

Figure 1-2
FFS Recommended EIB Treatment Area

Siltronic Corporation
Portland, Oregon

Legend

- Pilot Study Area
- Source Area Injections (4,092 square feet)

Note: Source area injections will occur between 26 and 106 feet below ground surface, except in the pilot study area where material injection may be limited to 26 to 50 feet below ground surface.
Source: Aerial Photograph (2006) obtained from Metro Data Resource Center

N

0 25 50
Feet

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File: X8128.01 Siltronic\20Fig\1-2_FFS Recommended EIB Treatment Area.mxd

Project: 8128.01.20 Produced By: T. Vick Approved By: E. Bakkom

Figure 1-3
Performance Data: PRB Wells WS-19-71/101
Siltronic Corporation
Portland, Oregon

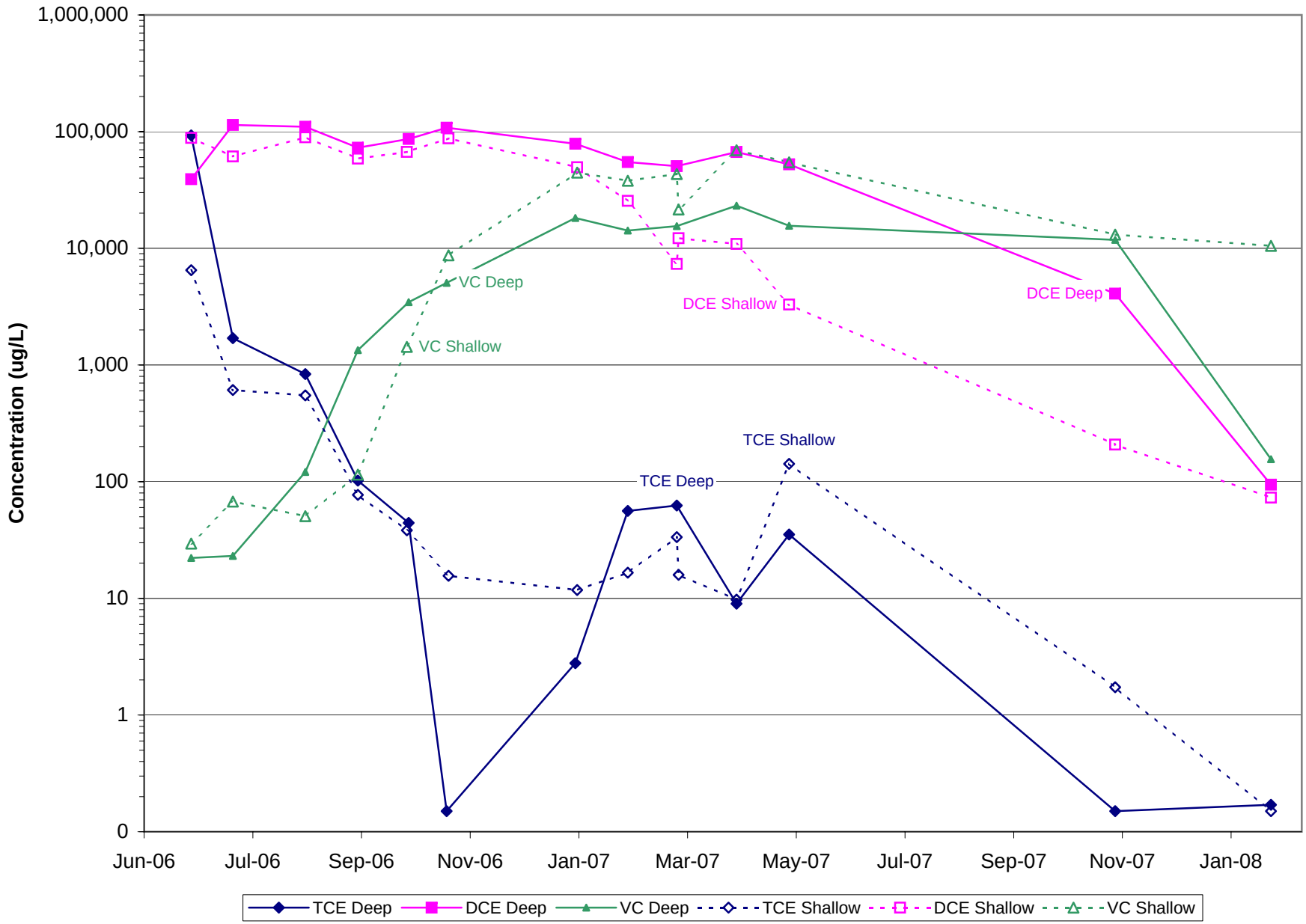

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Figure 1-4
Degradation Product Data: PRB Wells WS-19-71/101
Siltronic Corporation
Portland, Oregon

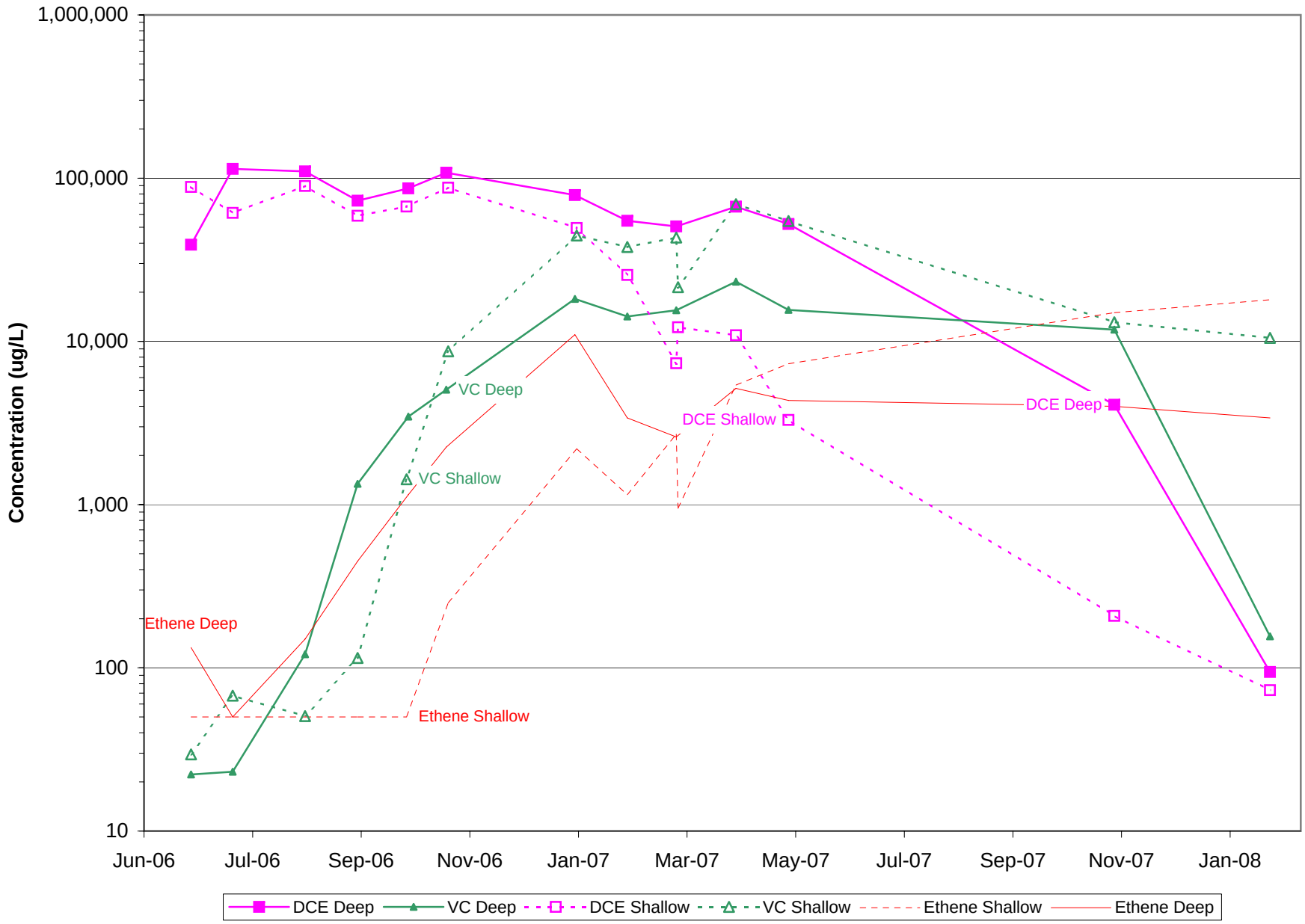

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Figure 1-5
Performance Data: Downgradient Wells WS-18-71/101
Siltronic Corporation
Portland, Oregon

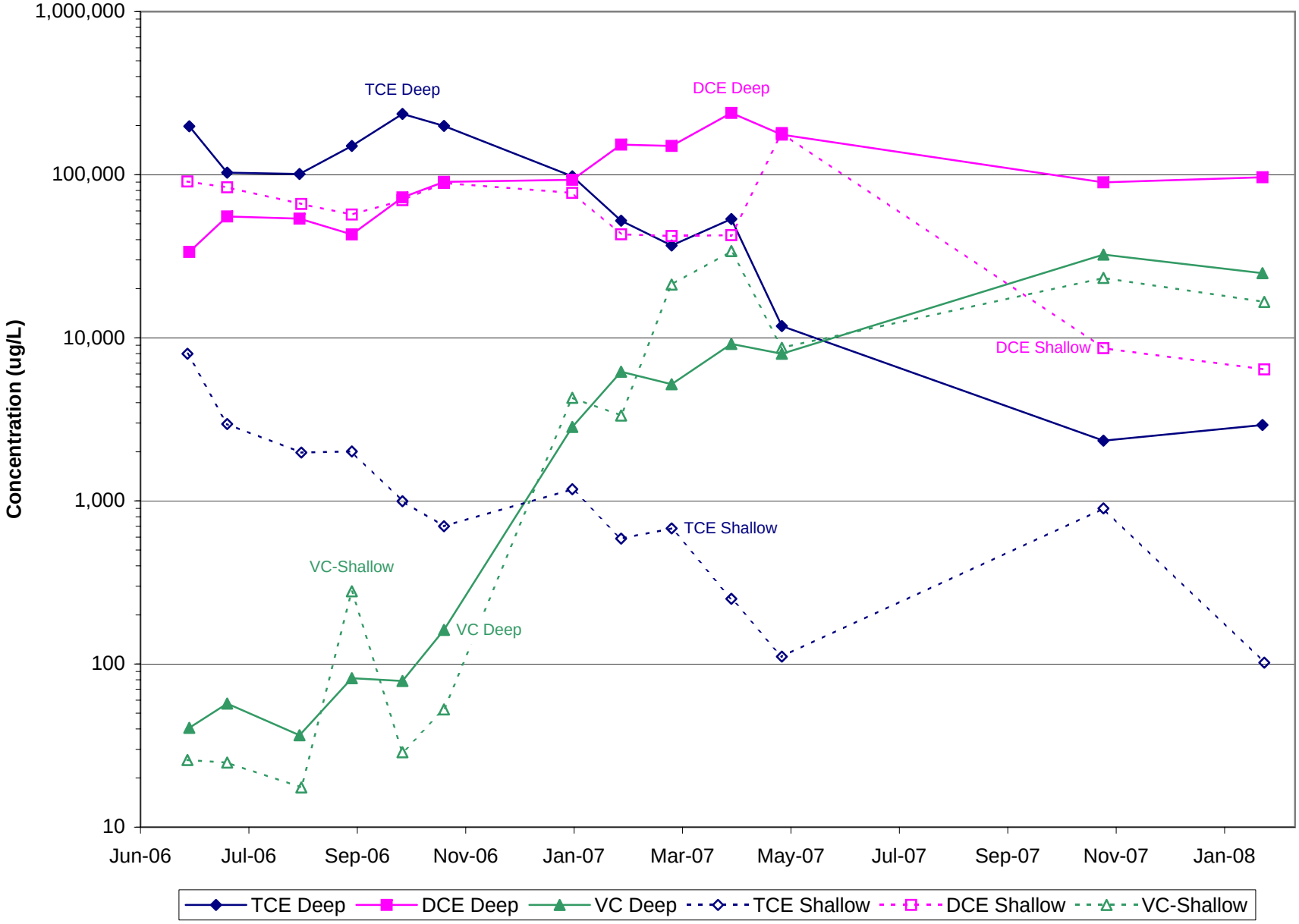

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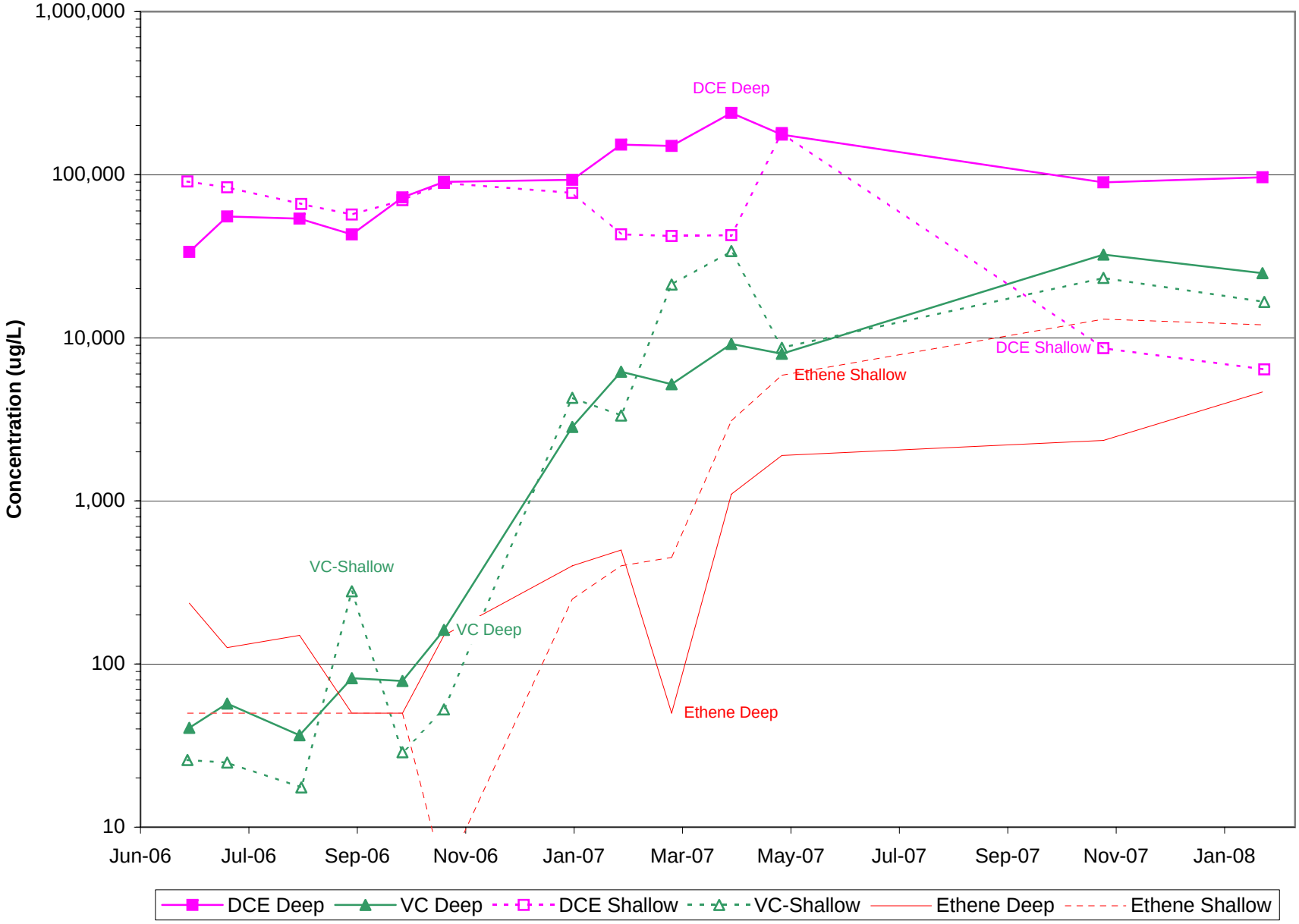
Figure 1-6
Degradation Product Data: Downgradient Wells WS-18-71/101
Siltronic Corporation
Portland, Oregon



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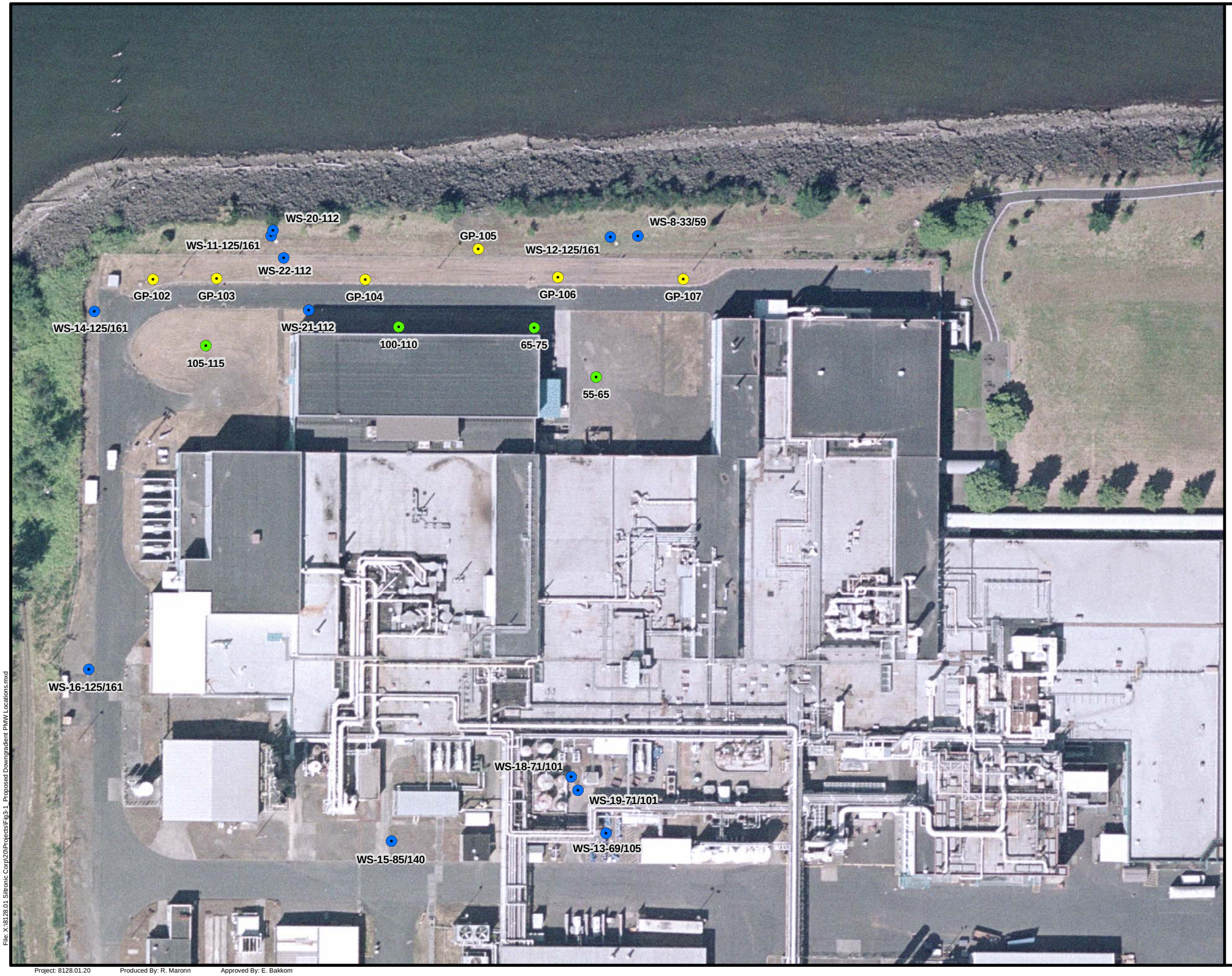

Figure 3-1
Proposed Downgradient PMW Locations

Siltronic Corporation
Portland, Oregon

Legend

- Geoprobe
- Existing Monitoring Well and Depth (Feet)
- Proposed Performance Monitoring Well and Screen Interval

Notes

* Only a portion of monitoring well and geoprobe locations is posted.
* Aerial Photograph (July 2005) obtained from Metro Data Resource Center

N

0 70 140
Feet

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Project: 8128.01.20 Produced By: R. Maronn Approved By: E. Bakkom

Figure 4-1
Degradation Product Forecast
PRB Well WS-19-101
Siltronic Corporation
Portland, Oregon

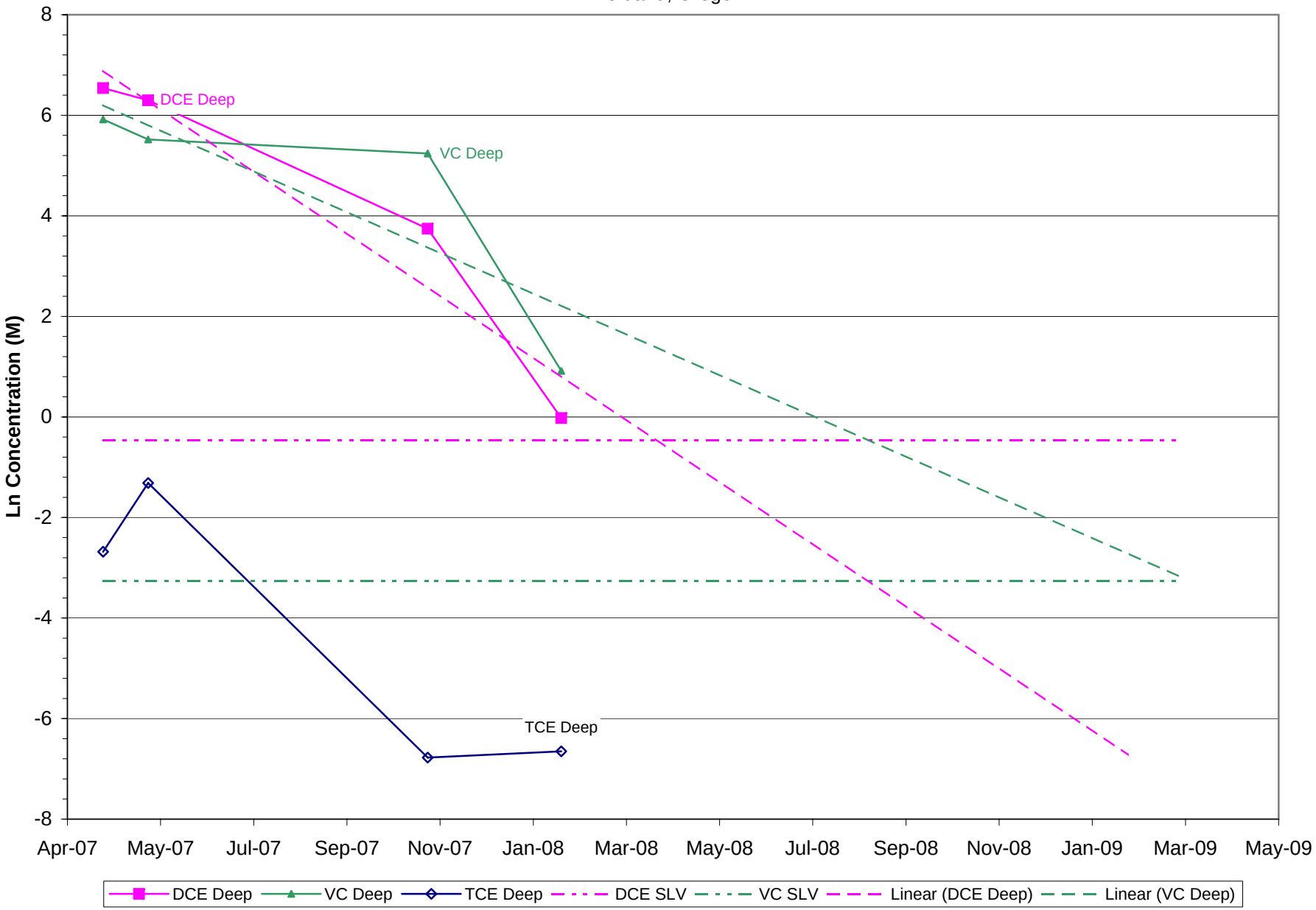

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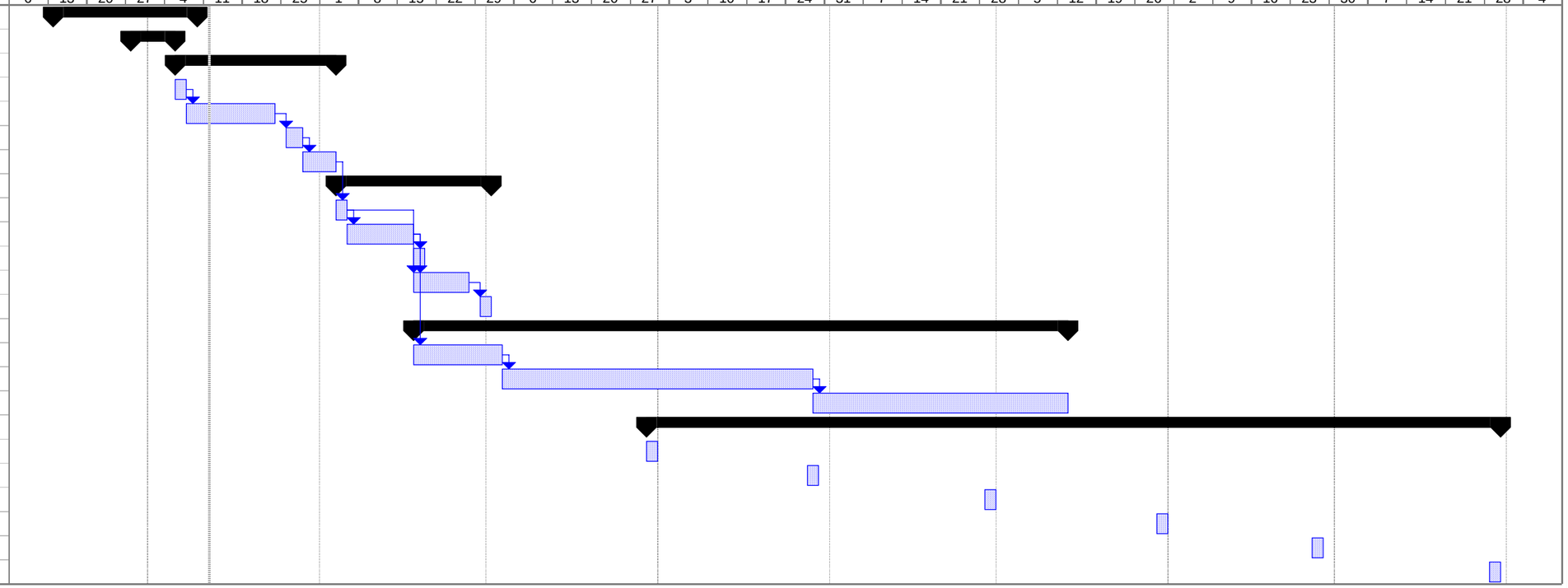
Figure 5-1
Source Area Injection Schedule, Summer 2008
Siltronic Corporation
Portland, Oregon

ID	Task Name
1	**Planning / Work Plans**
5	**Tank Farm Demolition**
7	**Delineation**
8	Air Knife/Utility Locate
9	Borings/Samples
10	Analysis Review
11	DEQ Review
12	**Monitoring Wells**
13	Air Knifing
14	SA Well Install
15	SA Install Pump and Sample
16	DG Well Install
17	DG Install Pump and Sample
18	**Injections**
19	Air Knife - Concrete Core
20	EHC Injections
21	KB-1 Injections
22	**Monitoring**
23	July
24	August
25	September
26	October
27	November
28	December



Project: Figure 5-1 Source Area Injecti
Date: Mon 5/12/08

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

APPENDIX A

RECENT PILOT STUDY DATA

Date: 05/09/2008

Table A-1
Chlorinated VOCs and Ethene in Groundwater
Source Area Pilot Study Wells - 11/2007 and 02/2008
Siltronic Corporation
Portland, Oregon

PERIOD: From 11/16/2007 thru 02/13/2008 - Inclusive
SAMPLE TYPE: Water

SITE	DATE	TCE (ug/l)	cis-1,2-DCE (ug/l)	trans-1,2-DCE (ug/l)	1,1-DCE (ug/l)	Vinyl chloride (ug/l)	Ethene (mg/l)
WS-18-101	11/16/2007	2340	89700	763	167	32400	2.35
WS-18-101	02/12/2008	2920	96400	757	158	24900	4.65
WS-18-71	11/16/2007	900	8640	104	29.0	23300	13.0
WS-18-71	02/13/2008	102	6400	107	34.2	16600	12.0
WS-19-101	11/19/2007	<0.3	4090	3.91	4.69	11800	3.80
WS-19-101	02/13/2008	0.370	94.3	<0.5	<0.5	156	3.40
WS-19-71	11/19/2007	1.73	208	2.64	<0.5	13100	15.0
WS-19-71	02/13/2008	<0.3	73.2	1.63	<0.5	10500	18.0

< - Analyte was not detected above the reporting limit.
ug/L - micrograms per liter; mg/L - milligrams per liter

APPENDIX B

PRE-INJECTION SCOPE OF WORK

MAUL FOSTER ALONGI INC.
3121 SW Moody Avenue, Suite 200 | Portland, Oregon 97239 | Phone 971.544.2139 | Fax 971.544.2140 | www.MFAinc.org

April 17, 2008
Project No. 8128.01.20

Mr. Dana Bayuk
Oregon Department of Environmental Quality
2020 SW 4th Avenue, Suite 400
Portland, Oregon 97201-4987

Re: Pre-Injection Scope of Work
Siltronic Corporation
7200 NW Front Avenue, Portland, OR
ECSI #183

Dear Dana:

On behalf of Siltronic Corporation (Siltronic), MFA has prepared the following scope of work for pre-injection activities. This scope of work was prepared based on the approach described in the Siltronic's Focused Feasibility Study (the FFS), which was submitted to the Oregon Department of Environmental Quality (DEQ) on October 23, 2007). The Siltronic FFS was prepared and submitted consistent with the requirements of the *Order Requiring Remedial Investigation and Source Control Measures*, DEQ No. VC-NWR-03-16 (the TCE Order). The TCE order required investigation of trichloroethene (TCE) and its degradation products (specifically, cis-1,2-dichloroethene (DCE) and its isomers, and vinyl chloride), and implementation of source control measures if necessary.

The FFS recommended enhanced *in-situ* bioremediation (EIB) for the source area, which includes the former underground storage tank (UST) area and the pilot study area (Figure 1). Access to the source area is limited due to the presence of facility equipment and utilities, both aboveground and subsurface. The FFS recommended additional delineation of TCE in groundwater below the source area, and identified potential areas where facility equipment could be removed to improve access. Siltronic received comments from DEQ regarding the FFS on February, 14, 2008; in their comments, DEQ concurred with the recommended approach for the source area. The source area scope of work was further refined during a scoping meeting with DEQ on April 9, 2008.

During the scoping meeting, MFA identified potential equipment removal options, and potential groundwater delineation boring locations. This letter provides additional detail

for equipment removal, identifies proposed boring locations, and describes the approach for TCE delineation.

AST Removal

The scope of work for this task includes demolition of the aboveground storage tank (AST) farm located adjacent to the former underground storage tank area (see Figure 1). The objective of the removal is to improve access for delineating TCE in groundwater, and potential injection points or monitoring wells. The ASTs replaced the former TCE UST system in approximately 1983. The tanks will be removed using a crane, and the concrete containment structure will be demolished. Surface piping (air, electrical, product) will be disconnected as well. Two air return tanks located adjacent to the AST farm may also be removed, if possible. MFA will collect samples of concrete from below the tanks and from the containment sump to allow for proper disposal of the concrete.[1]

Supplemental TCE Delineation

The objective of the supplemental delineation is to further characterize the vertical and lateral distribution of TCE in groundwater below the source area. The scope of work will include collecting reconnaissance groundwater samples and pneumatic slug test data. The equipment and methods for the delineation will be consistent with the approach for the supplemental riverbank delineation (2007) and the previous pilot study area investigation (2006).

Based on DEQ's comments and the scoping meeting, MFA identified ten initial locations for reconnaissance groundwater sampling in or near the source area (see Figure 1). Four samples will be attempted from each boring, at approximate depths of 25, 50, 75, and 100 feet below ground surface. Samples will be analyzed for volatile organic compounds (VOCs) on accelerated turn-around times. Preliminary results will be forwarded to DEQ as they become available to facilitate decisions about revising the approach, if necessary.

The results of the supplemental delineation will be used to identify an approximate area where TCE concentrations in groundwater exceed one percent of the aqueous solubility limit (i.e., approximately 11,000 ug/L). Consistent with the recommendations in the FFS, this area will be the priority for EIB injection.

During the scoping meeting, DEQ acknowledged that the delineation results will not be available for submittal with the work plan. The results will therefore be submitted as an

[1] If TCE is detected in the concrete samples, the concrete will be disposed of in an appropriate Subtitle C facility (e.g., ChemWaste Management – Arlington). If TCE is not detected, the concrete will be recycled.

addendum to the work plan. MFA has contacted subcontractors and developed tentative schedules. We look forward to DEQ's approval of this scope of work.

Please call either of us at (971) 544-2139 if you have questions or comments.

Sincerely,

Maul Foster & Alongi, Inc.

James G.D. Peale, R.G.
Senior Hydrogeologist

James J. Maul, R.G.
Principal Hydrogeologist

Attachments: Figure 1 – Proposed Source Area Supplemental Delineation

cc: Tom McCue, Siltronic
Chris Reive, Jordan Schrader Ramis P.C.
Alan Gladstone and William Earle, Davis Rothwell Earle & Xochihua, P.C.
Jim Anderson, DEQ/PHS
Matt McClincy, DEQ/PHS

Figure 1
Proposed Source Area Supplemental Delineation

Siltronic Corporation
Portland, Oregon

Legend

- Geoprobe Location
- Pilot Study Injection Point
- Monitoring Well
- Proposed Boring
- ASTs and Containment to be Removed
- Inaccessible Areas
- Pilot Study Area

Note:
Proposed boring locations are approximate and subject to field modification based on potential buried utilities and/or preliminary results.

Source: Aerial Photograph (2007) obtained from Metro Data Resource Center

N

0 20 40
Feet

MAUL FOSTER ALONGI INC.
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File: X:\8128.01 Siltronic Corp\12\Fig1_Proposed Source Area Supplemental Delineation.mxd

Project: 8128.01.12 Produced By: B. Hines Approved By: E. Bakkom

James Peale

From: BAYUK Dana [BAYUK.Dana@deq.state.or.us]

Sent: Friday, April 25, 2008 3:28 PM

To: James Peale

Cc: McCue, Tom; Gladstone, Alan; GAINER Tom; LARSEN Henning

Subject: Siltronic, Pre-Injection Scope of Work

Hello James.

The Oregon Department of Environmental Quality (DEQ) reviewed the "Pre-Injection Scope of Work - Siltronic Corporation, 7200 NW Front Avenue, Portland, OR - ECSI #183" dated April 17, 2008 (Scope of Work). Maul Foster Alongi, Inc. prepared the Scope of Work for the Siltronic Corporation (Siltronic).

The Scope of Work presents Siltronic's approach to further evaluate the nature and extent of trichloroethene, including its breakdown products and additives (collectively referred to as "VOCs" in this e-mail), in the vicinity of the former solvent underground storage tank system (Former UST System). Historic releases of VOCs from the Former UST System have contaminated groundwater beneath the northern portion of the Siltronic site. The data generated from the drilling and sampling work described in the Scope of Work will support a plan for using enhanced in-situ bioremediation (EIB) to reduce concentrations of VOCs.

DEQ understands Siltronic's proposed Scope of Work includes the following work items:

- Demolishing above-ground storage tanks that are no longer in use and located in the area of investigation;
- Drilling ten push-probe borings in and around the Former UST System area to a depth of approximately 100 feet below ground surface (bgs);
- Collecting reconnaissance groundwater samples at depths of 25, 50, 75, and 100 feet bgs for expedited analysis of VOCs;
- Conducting pneumatic slug tests in selected borings to develop representative estimates of horizontal hydraulic conductivity within the investigation area; and
- Preparing and submitting a report that documents the work completed as an addendum to the EIB implementation plan (the implementation plan is due to DEQ on May 7th).

DEQ further understands the data produced from the expedited analysis of reconnaissance groundwater samples will be used to modify the drilling and sampling program as needed (e.g., adjusting and/or adding boring locations, altering the sampling intervals and/or frequency).

DEQ approves the drilling, sampling, and analytical work described in the Scope of Work with the following modifications.

- Consistent with work completed previously to support the EIB pilot study, four reconnaissance groundwater samples (approximately equally vertically spaced) should be collected for VOC analysis from 50 to 100 feet bgs. As such, five samples should be collected from each boring (i.e., one sample from ~25 feet bgs, and four samples from between 50 and 100 feet bgs).
- DEQ understands that borings will be advanced with the purpose of collecting reconnaissance groundwater samples. DEQ expects at least three of the borings to be continuously logged during drilling to supplement stratigraphic observations made previously. The borings selected for geologic logging should be located east, west, and as far north as practicable of the source zone pilot study area.
- Siltronic has previously interpreted the lower extent of VOCs in the vicinity of the Former UST System area to correspond with fine-grained sediments that occur between 100 and 105 feet bgs. DEQ expects samples of this material to be collected from the three borings selected for continuous logging. Each of these samples should be collected and tested with the objective of obtaining representative estimates of

vertical hydraulic conductivity for the undisturbed material.

Based on our telephone conversation on Wednesday April 23rd, DEQ understands the drilling and sampling work discussed in this e-mail have been tentatively scheduled to begin the week beginning May 5th. DEQ is not requesting the Scope of Work to be revised and resubmitted, however prior to initiating field activities Siltronic should provide written confirmation that the modifications listed above will be incorporated into the drilling, sampling, and analytical program.

Please feel free to contact me with questions regarding this e-mail.

Mr. Dana Bayuk, Project Manager
Cleanup & Portland Harbor Section
Oregon Department of Environmental Quality
2020 SW 4th Avenue, Suite 400
Portland, OR 97201

E-mail: bayuk.dana@deq.state.or.us
Phone: 503-229-5543
FAX: 503-229-6899

Please visit our website at http://www.oregon.gov/DEQ/